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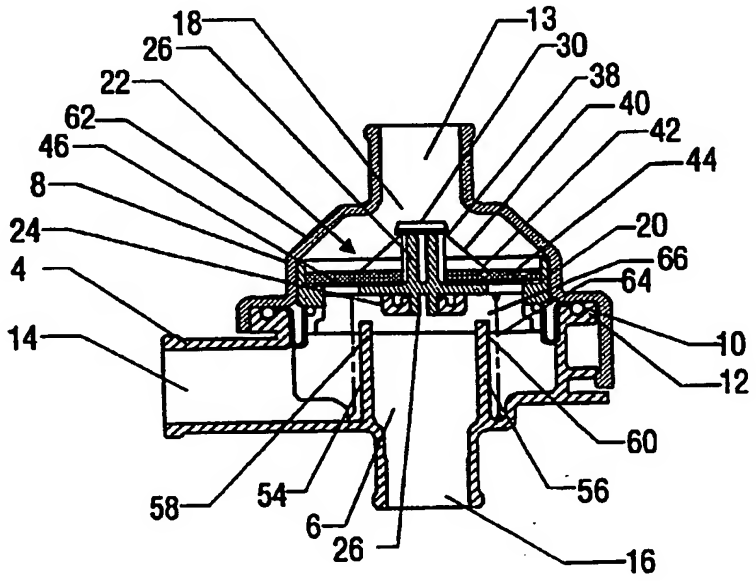
(54) Title: PRESSURE REGULATING PISTON WITH BUILT IN RELIEF VALVE



(57) Abstract: A pressure regulating valve particularly useful in diesel internal combustion engine with a closed crankcase is provided. The valve includes a body (10) coupled to a bonnet (62) with an internal moveable piston (20). The moveable piston (20) maintains a substantially constant pressure in the crankcase by adjusting a fluid flow in response to changes in pressure. The piston (20) also includes an integral relief valve (44) to prevent overpressure in the event of a crankcase pressure in excess of the designed limits of the pressure regulating valve.

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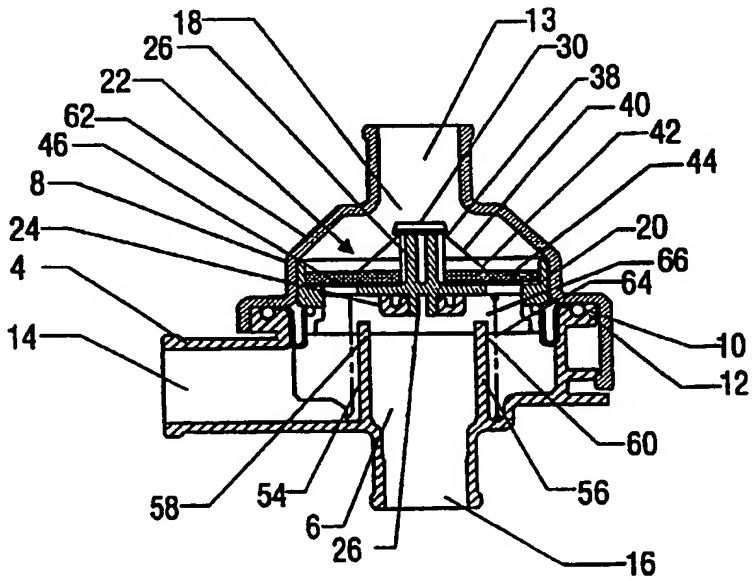

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PRESSURE REGULATING PISTON WITH BUILT IN RELIEF VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

This Application claims priority of the Provisional Application No. 60/207,079 filed May 25, 2000.

FIELD OF THE INVENTION

This invention relates generally to engine valve apparatus and, more particularly, to a pressure regulating piston valve with a built in relief valve.

BACKGROUND OF THE INVENTION

As engine manufacturers reduce exhaust emissions, crankcase blow-by vented to the atmosphere has become a larger contributor to the total emissions. Crankcase blow-by is produced when combustion gases, under high pressure, become contaminated with oil mist when blown past the piston rings into the crankcase. To further reduce the total emissions of engines, it has become necessary to rout these gases into the air intake system. In a closed system, this contaminated blow-by is ingested by the engine intake system.

Interest in closed crankcases is being driven both by regulatory as well as operating concerns. As of January 1, 1998, the U.S. Environmental Protection Agency (EPA) required that all gaseous-fueled on-highway engines must have a closed crankcase. While there are as yet no specific regulations on closing the crankcases of diesel engines, the overall drive to reduce emissions has made most engine and equipment manufacturers become more interested in closing their crankcases.

In a closed crankcase system, crankcase blow-by gases, which inherently cause a rise in crankcase pressure, need to be routed back into the engine intake system. Excessive variations in crankcase pressure can damage seals and cause a loss of oil. There is a perceived need for a pressure regulator to minimize variation in crankcase pressure. There is also a perceived need for a relief valve to protect against overpressure in the crankcase that cannot be compensated for by the regulator itself.

The present invention is directed to overcoming, or at least reducing the effects of, one or more of the issues set forth above.

SUMMARY OF THE INVENTION

One aspect of the present invention provides a pressure-regulating valve, including a body, a movable piston, and a relief valve. The body has a fluid passageway therethrough. The movable piston is disposed within the body and is movable in response to pressures thereon to adjust a fluid flow through the fluid passageway. The relief valve is integral to the piston. At least one hole in the piston is exposed to a relief passageway upon the application of a predetermined level of pressure on the piston.

Another aspect of the present invention provides a pressure-regulating valve, including an upper body portion, a lower body portion, a movable piston and a spool. The upper body portion is in fluid communication with a crankcase. The lower body portion isolated fluidly from the upper body portion and having a lower body fluid passageway therethrough in communication with a crankcase and a vacuum source. The movable piston is disposed within the upper body portion. The piston is movable in response to pressure thereon to adjust a fluid flow through the lower body fluid passageway. The spool connected to the piston and extending through the upper body portion and to the lower body portion.

Yet another aspect of the present invention provides a method of regulating pressure in a crankcase of an internal combustion engine. The method includes providing a crankcase valve responsive to crankcase pressure, wherein changes in crankcase pressure are communicated to the crankcase valve; adjusting a flow through the crankcase valve to correspondingly alter the crankcase pressure; and releasing overpressure in the crankcase through a relief valve integral to the crankcase valve upon application of a predetermined amount of pressure.

The foregoing summary is not intended to summarize each potential embodiment or every aspect of the invention disclosed herein, but merely to summarize the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing summary, preferred embodiments and other features or aspects of the invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

FIG 1 is a cross-sectional view of a valve design in accordance with one aspect of the invention.

FIG 2 is a top view of the design according to FIG 1.

FIG 3 is a cross-sectional view of an alternative valve design according to one aspect of the invention.

FIG 4 is a top view of the design according to FIG 3.

FIG 5 is a top view of a valve piston in accordance with one aspect of the invention.

FIG 6 is a cross-sectional view of the design according to FIG 5.

FIG 7 is a detail of the circled area of FIG 6.

FIG 8 is a cross-sectional view of a flow shaper design according to the invention.

FIG 9 is a top view of the design according to FIG 8.

FIG 10 is a side view of a plug in accordance with the invention.

FIG 11 is a top view of a relief disc design in accordance with the invention.

FIG 12 is a cross-sectional view of the relief disc shown in FIG 11.

FIG 13 is a top view of a sealing disc design in accordance with the invention.

FIG 14 is a side view of the sealing disc shown in FIG 13.

FIG 15 is a cross-sectional view of a proportioning spool in accordance with the invention.

FIG 16 is a cross-sectional view of an alternative embodiment for the valve in accordance with the invention.

FIG 17 is a top view of the valve shown in FIG 16.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. The figures and written description are not intended to limit the breadth or scope of the invention in any manner, rather they are provided to

illustrate the invention to a person of ordinary skill in the art by reference to particular embodiments of the invention, as required by 35 USC § 112.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to the figures, and in particular to FIG 1, a pressure-regulating valve in accordance with one embodiment of the invention is disclosed. Pressure regulating valve may be used in equipment including, but not limited to, gas engines, diesel engines, generator sets and other power equipment. As shown in FIG 1, pressure-regulating valve includes a body with a fluid passageway extending therethrough. Fluid passageway may facilitate, for example, fluid communication between a crankcase (not shown) and a vacuum source (not shown). In the embodiment shown in FIG 2, fluid passageway exhibits an inlet and an outlet that are substantially normal to one another, but this is not necessarily so. In other embodiments discussed in more detail later in this disclosure the inlet and outlet are arranged parallel to one another. It will be understood by one of skill in the art with the benefit of this disclosure that inlet and outlet may be arranged in any convenient manner. In the embodiment of FIG 1, use of pressure regulating valve is integrated into a diesel engine (not shown) with a closed crankcase to facilitate reduced emissions.

Attached to body is a bonnet. A diaphragm, preferably a rolling diaphragm such as is available from Bellofram, Inc., is disposed between body and bonnet. Rolling diaphragm fits into a groove formed in body and provides a gas-tight seal between body and bonnet. Bonnet includes a relief flow passageway isolated from fluid passageway in normal operation. Relief flow passageway may lead directly to atmosphere, or it may lead back to an engine intake manifold (not shown).

A movable piston assembly is disposed inside body and bonnet. Piston assembly includes a piston that is also part of an integrated relief valve. Piston includes at least one hole, for example the six holes equally spaced around the circumference of the piston as shown in FIG 5. Piston includes at least one guide/stop leg, for example the four guides/stops equally spaced around the circumference of the piston as shown in FIG 5, to guide piston inside bonnet and to stop piston travel on angled wall of bonnet. Piston is shown in some detail in FIGS 5-7. Piston assembly may also include a flow shaper attached to a nipple of piston. Flow shaper is shown in some detail on FIGS 8

and 9. Flow shaper may have a generally U-shaped cross-section and facilitates less turbulent flow through fluid passageway. Opposite nipple of piston is a channel receptive of a plug. Plug is shown in detail on FIG 10 and includes a stem with a raised portion(s) to facilitate attachment to piston. A head of plug retains a first end of a biasing member, such as a conical spring. Conical spring exhibits a second end that abuts relief disc. Relief disk is shown in detail in FIGS 11 and 12 and includes a hole to accommodate piston channel and includes a groove into which a second end of conical spring fits. Relief disk may comprise, but it not limited to, Ryton R-4XT.

Between relief disk and piston is a sealing disk. Sealing disk is shown in FIGS 13 and 14 and exhibits a hole that also accommodates piston channel. Sealing disk may comprise, but is not limited to, a Buna-N copolymer with durometer hardness. Sealing disk is sandwiched between piston and relief disk by a force provided by conical spring. Sealing disk seals holes in piston. When a sufficient predetermined force is applied to sealing disk from inside body, the force of conical spring may be overcome and allow for fluid communication between fluid passageway and relief flow passageway.

Body exhibits opposing internal walls and, which are parts of fluid flow passageway. First ends of internal walls, respectively, provide a limit to the travel of piston within body. In FIG 1, piston is in the full-open position with guide/stop legs abutting angled wall of bonnet. Piston may also travel between the position shown in FIG 1 and a position in which the piston abuts ends, closing off fluid communication between inlet and outlet of fluid flow passageway. A biasing member, for example coiled compression spring extending between piston and body, biases piston to an open position as described above with guide/stop legs of piston abutting angled wall of bonnet. Pressure, positive or negative, transmitted from, for example, the crankcase or vacuum source (not shown) may overcome the force supplied by coiled compression spring to move piston to the position shown in FIG 1, or to any position in between the closed position and the full open position of FIG 1. Rolling diaphragm seals the annulus between piston and either bonnet (in the full open position as shown in FIG 1) or body (in the closed position), or both bonnet and body.

The operation of pressure regulating valve is described as follows. Pressure-regulating valve may be positioned, for example, in a diesel engine comprising a closed

crankcase (not shown). As the diesel engine runs some blow-by will occur and inherently cause the pressure in the closed crankcase to increase. It is desirable to keep the pressure in the crankcase regulated for reasons discussed in the background section. As the force on the piston due to crankcase pressure and coiled compression spring varies relative to the force on piston due to the vacuum source, piston travels advantageously toward either bonnet or ends of body. When this occurs a gap between ends and piston changes accordingly and regulates the flow past flow shaper and through fluid passageway, thus regulating the crankcase pressure. Thus, piston adjusts itself relative to the forces applied to it, by crankcase pressure, vacuum source, and coiled compression spring, to maintain a substantially constant pressure in the crankcase. In the event that the crankcase pressure exceeds the range under which pressure-regulating valve is intended to operate, integral relief valve opens, i.e. fluid communication between fluid flow passageway and relief flow passageway is established through holes of piston. The seal between holes and sealing disk breaks as pressure on the piston increases sufficiently to overcome the force on relief disk provided by conical spring.

A second embodiment of the invention is similarly disclosed in FIGS 3, 4 and 15. In the embodiment shown in these figures, all of the components shown in FIG 1 are included in pressure-regulating valve, however, this second embodiment includes some modifications. Body of pressure-regulating valve includes an upper portion and a lower portion. Lower portion includes a fluid passageway with an inlet and outlet substantially parallel to one another. Fluid passageway may facilitate, for example, fluid communication between a crankcase (not shown) and a vacuum source (not shown). It will be understood by one of skill in the art with the benefit of this disclosure that the arrangement of the inlet and outlet may be adjusted as necessary to fit within the engine parameters. Upper portion includes a fluid passageway with an inlet. Inlet may facilitate, for example, fluid communication between a crankcase and fluid passageway. A flow shaper is included in lower body to reduce turbulent flow characteristics. In the embodiment shown in FIG 3, flow shaper is generally U-shaped, but it may also be straight or otherwise adjusted. There is no need for an additional flow shaper to be added to piston. This absence of an additional flow shaper can be tolerated because in the embodiment shown in FIGS 3, 4, and 15, there is no fluid communication between the upper portion and the lower portion, as there may be for the embodiment shown in

FIG 1. In this embodiment proportioning spool in the lower body, may take the place of flow shaper of valve shown in Fig 1.

Pressure regulating valve as shown in FIG 3 also includes a proportioning spool that attaches at a first end to piston and extends through upper body and into lower body, where it passes through flow orifices which separate inlet from outlet. As proportioning spool travels with piston assembly, the flow orifices open and close. Proportioning spool is shown in detail in FIG 15 and includes a stem with a groove to facilitate attachment of first end to piston. The main body of proportioning spool may exhibit a slot or slots to reduce mass. In some embodiments, there are four fins that keep wall thickness uniform for molding and thus reduce the mass of proportioning spool. Main body may exhibit a channel to allow fluid communication between inlet and outlet and to connect the tapered areas of the proportioning spool. Proportioning spool may exhibit tapered areas to regulate the amount of flow passing through orifices.

Referring again to FIG 3, an O-ring held in place by an O-ring retainer seals the annulus between proportioning spool and upper body. A gap between a second end of proportioning spool and a flow orifice disposed in lower body allows for maximum fluid flow through fluid passageway in the full open position shown in FIG 3. Coiled compression spring biases piston and thus proportioning spool to the open position shown with tapered areas of proportioning spool in a position which allows maximum fluid flow through flow orifices and thus passageway.

The piston, diaphragm, relief valve assembly and other components of pressure regulating valve are identical to the corresponding components described for pressure regulating valve.

Operation of pressure regulating valve is as follows. During engine operation, as crankcase and vacuum source pressure varies, the force on piston correspondingly varies, this varying force is balanced by coiled compression spring which exerts a force equal in magnitude but opposite in direction to the force created by the crankcase and vacuum source pressure. As this occurs, piston and proportioning spool which is rigidly attached thereto advantageously position to increase or decrease the flow orifice areas, thus increasing or decreasing the fluid flow through fluid flow passageway. The increased or

decreased flow through fluid passageway results in a regulated crankcase pressure. Piston and thus proportioning spool will self-adjust according to crankcase pressure, vacuum source pressure and the force supplied by coiled compression spring to maintain a substantially constant pressure in the crankcase. In the event of crankcase pressure exceeding the range pressure regulating valve is intended to operate under, integral relief valve assembly advantageously opens, i.e. fluid communication between fluid flow passageway and relief flow passageway is established through holes of piston. The seal between holes and sealing disk breaks as pressure on the piston increases sufficiently to overcome the force on relief disk provided by conical spring.

In an alternative embodiment shown in FIGS 16-17, piston does not include a separate insertable plug or flow shaper but instead comprises a single piece. Piston includes a head at first end where it meets conical spring and an integral flow shaper at second end. This alternative embodiment does not include the optional flow shapers of the other embodiments, but otherwise, the components, including the operation of relief valve, are identical to the embodiment shown in FIG 1.

In some applications, the pressures at which pistons are operable are as follows. Pistons may be biased in the open positions shown in the figures at atmospheric pressure, and may close proportionally at a pressure differential of approximately two to 10 inches of water. As crankcase pressure tends to increase, pistons will open until the full open position (shown) is reached at a pressure of approximately ten inches of water. At any pressures greater than ten inches of water, relief valves open and release the excess crankcase pressure. It will be understood by one of skill in the art with the benefit of this disclosure, however, that these pressure ranges are only exemplary, and that the springs and valves may be designed to meet any other pressure ranges as necessary.

While the present invention has been particularly shown and described with reference to a particular illustrative embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention. The above-described embodiment is intended to be merely illustrative, and should not be considered as limiting the scope of the present invention.

CLAIMS:

1. A pressure-regulating valve comprising:

a body with a fluid passageway therethrough;

a movable piston disposed within the body and movable in response to pressures thereon to adjust a fluid flow through the fluid passageway; and

a relief valve integral to the piston, wherein at least one hole in the piston is exposed to a relief passageway upon the application of a predetermined level of pressure on the piston.

2. The pressure-regulating valve of claim 1, further comprising a bonnet coupled to the body with the relief fluid passageway therein.

3. The pressure-regulating valve of claim 1, wherein movement of the moveable piston regulates pressure by allowing varying volumes of fluid to pass through the fluid passageway.

4. The pressure-regulating valve of claim 1, further comprising a flow shaper attached to the piston to alter flow through the fluid passageway.

5. The pressure-regulating valve of claim 1, wherein the relief valve comprises:

a plug disposed within a channel of the piston;

a sealing disc adjacent to the at least one hole in the pistona relief disc adjacent to the sealing disc; and

a relief valve spring disposed between the plug and a relief disc biasing the relief disc and thus sealing disc to a closed, sealed position covering the at least one hole in the piston.

6. The pressure-regulating valve of claim 1, further comprising at least one biasing member between the piston and the body, the at least one biasing member biasing the piston to an open position.

7. The pressure-regulating valve of claim 2, further comprising a seal between the bonnet and the body.

8. The pressure-regulating valve of claim 7, wherein the seal comprises a rolling diaphragm.

9. The pressure regulating valve of claim 1, wherein the apparatus is used to regulate crankcase pressure in an internal combustion engine.

10. The pressure regulating valve of claim 9, wherein the internal combustion engine is a diesel engine.

11. A pressure regulating valve comprising:

an upper body portion in fluid communication with a crankcase;

a lower body portion isolated fluidly from the upper body portion and having a lower body fluid passageway therethrough in communication with a crankcase and a vacuum source;

a movable piston disposed within the upper body portion; wherein the piston is movable in response to pressure thereon to adjust a fluid flow through the lower body fluid passageway; and

a spool connected to the piston and extending through the upper body portion and to the lower body portion.

12. The pressure regulating valve of claim 11, further comprising a relief valve integral to the piston wherein at least one hole in the piston is openable upon the application of a predetermined level of pressure on the piston.

13. The pressure regulating valve of claim 11, further comprising a bonnet coupled to the upper body with a relief fluid passageway therein.

14. The pressure regulating valve of claim 11, wherein movement of the moveable piston regulates pressure by allowing varying volumes of fluid to pass through the lower body fluid passageway by altering the dimensions of a passageway gap between the spool and the lower body.

15. The pressure regulating valve of claim 11, further comprising a flow shaper within the lower body portion facilitating fluid flow through the lower body fluid passageway.

16. The pressure regulating valve of claim 12, wherein the relief valve comprises:
a plug disposed within a channel of the piston;
a sealing disc adjacent to the at least one hole in the piston;
a relief disc adjacent to the sealing disc; and
a relief valve spring disposed between the plug and relief disc biasing the relief disc and thus sealing disc to a closed, sealed position covering the at least one hole in the piston.

17. The pressure regulating valve of claim 11, further comprising at least one spring between the piston and the upper body portion, the at least one spring biasing the piston to an open position.

18. The pressure regulating valve of claim 13, further comprising a seal between the bonnet and the upper body portion.

19. The pressure regulating valve of claim 18, wherein the seal comprises a rolling diaphragm.

20. The pressure regulating valve of claim 11, wherein the apparatus is used to regulate crankcase pressure in an internal combustion engine.

21. The pressure regulating valve of claim 20, wherein the internal combustion engine is a diesel engine.

22. A method of regulating pressure in a crankcase of an internal combustion engine comprising:
providing a crankcase valve responsive to crankcase pressure, wherein changes in crankcase pressure are communicated to the crankcase valve;

adjusting a flow through the crankcase valve to correspondingly alter the crankcase pressure; and

releasing overpressure in the crankcase through a relief valve integral to the crankcase valve upon application of a predetermined amount of pressure.

23. The method of claim 22, wherein the crankcase valve comprises:

a body with a fluid passageway therethrough;

a movable piston disposed within the body and the bonnet; wherein the piston is movable in response to pressure thereon to adjust a fluid flow through the body fluid passageway; and

a relief valve integral to the piston wherein at least one hole in the piston is exposed to the relief passageway upon the application of a predetermined level of pressure on the piston.

24. The method of claim 23, wherein the crankcase valve further comprises a bonnet coupled to the body with a relief fluid passageway therein.

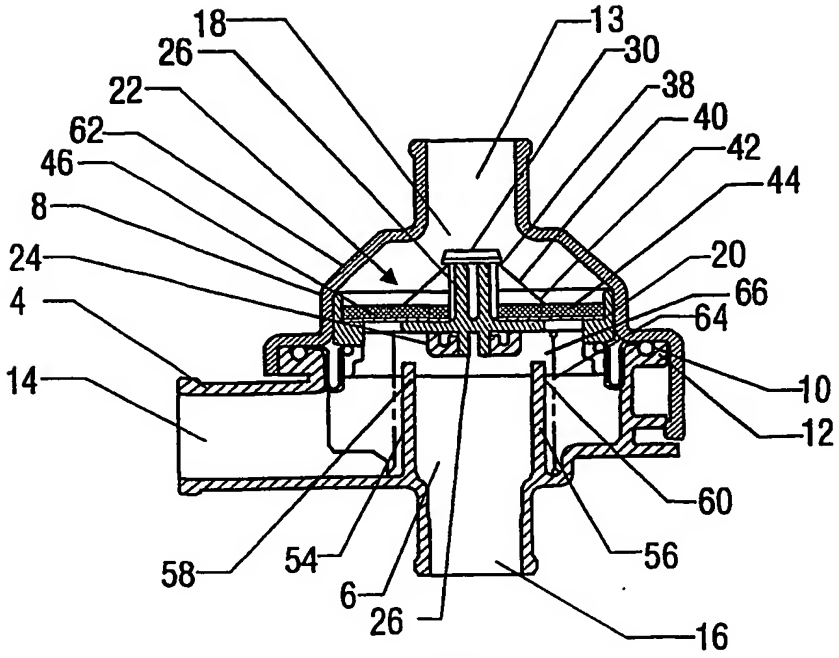
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FIG. 1

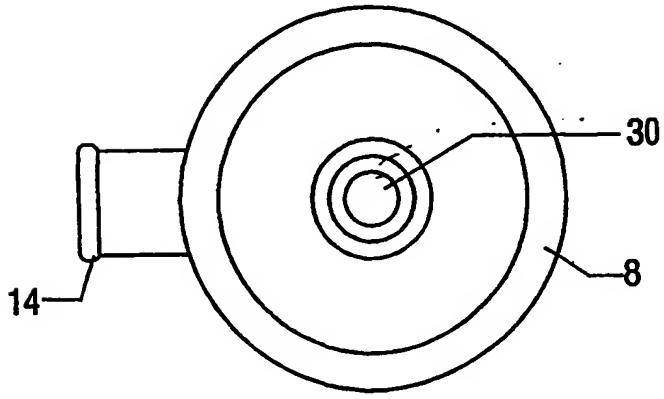
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FIG. 2

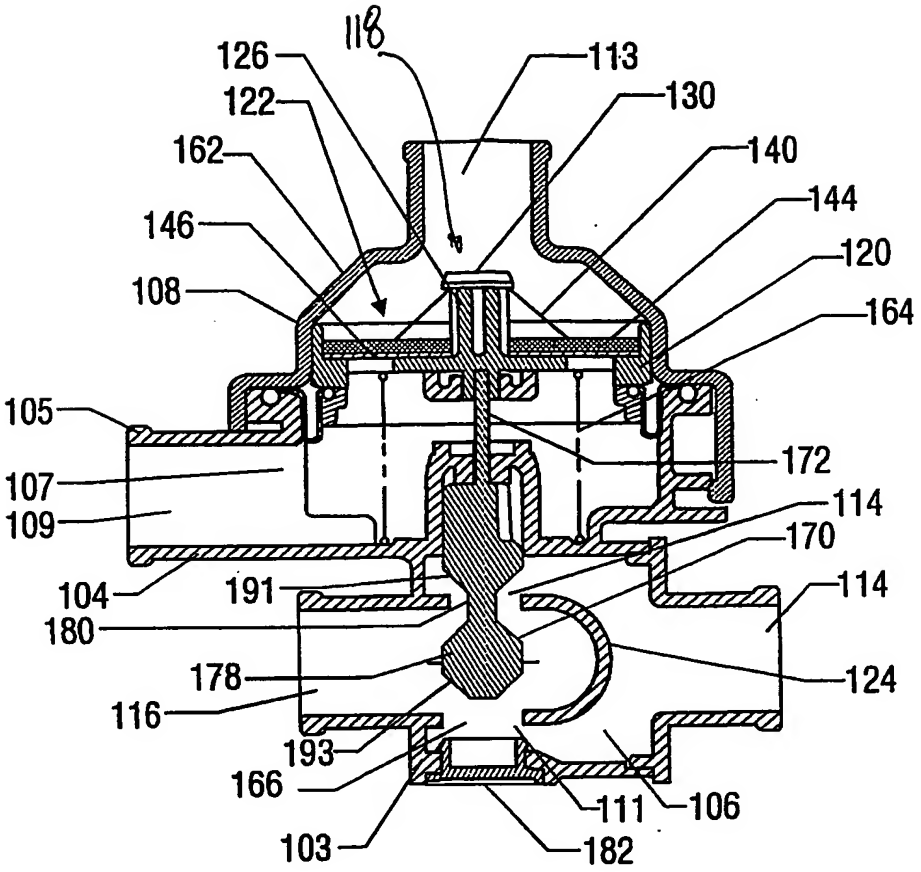
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FIG. 3

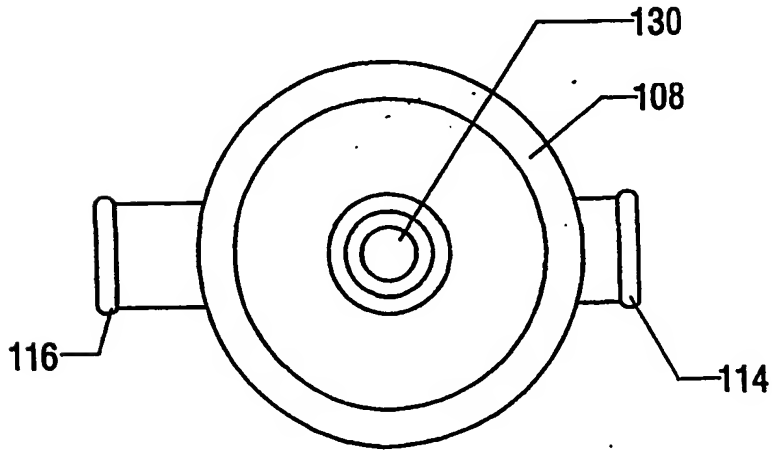
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FIG. 4

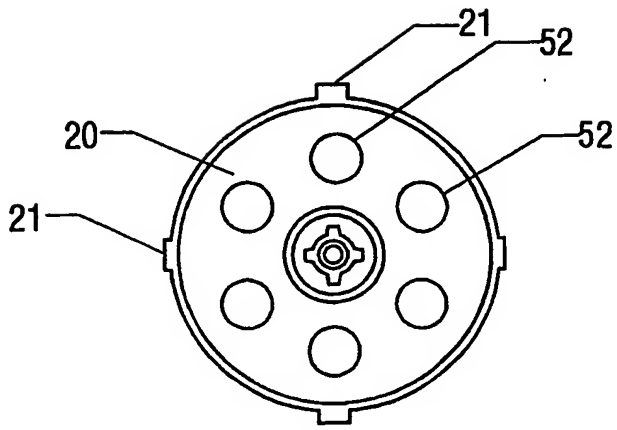

FIG. 5

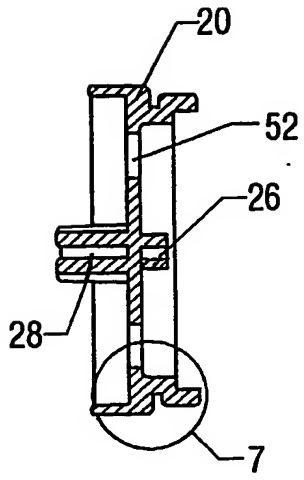

FIG. 6

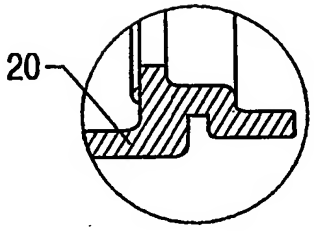

FIG. 7

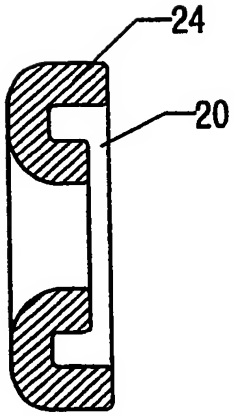

FIG. 8

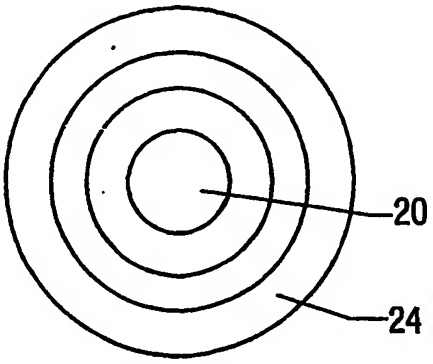

FIG. 9

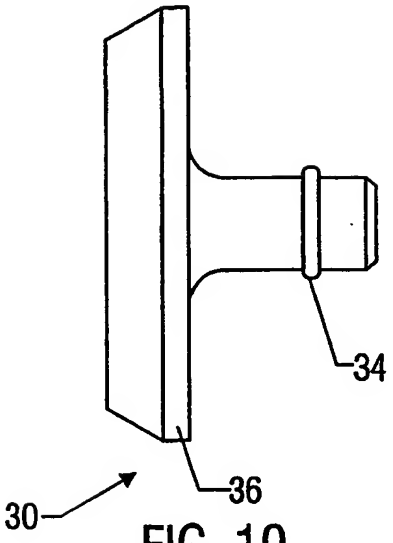

FIG. 10

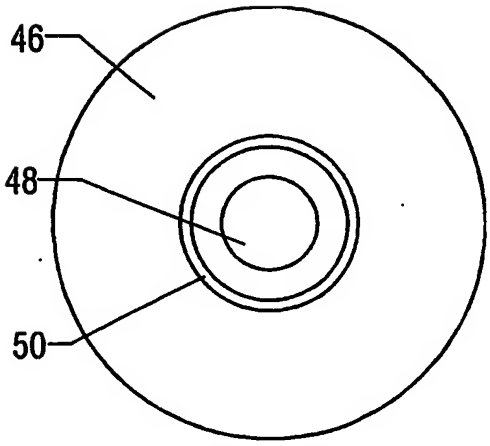

FIG. 11

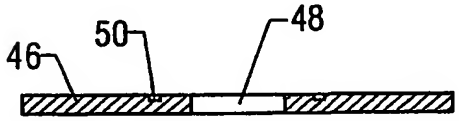

FIG. 12

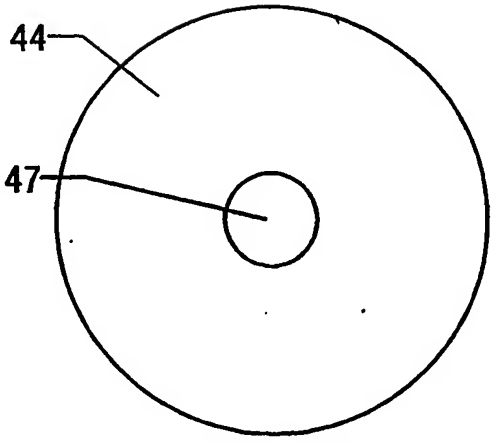

FIG. 13

FIG. 14

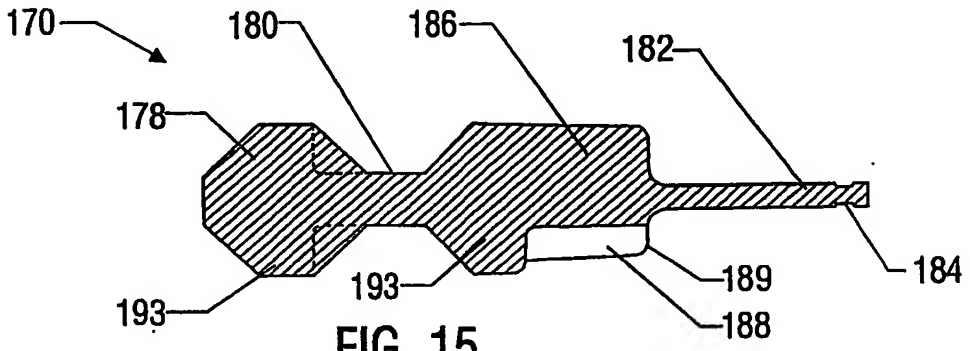

FIG. 15

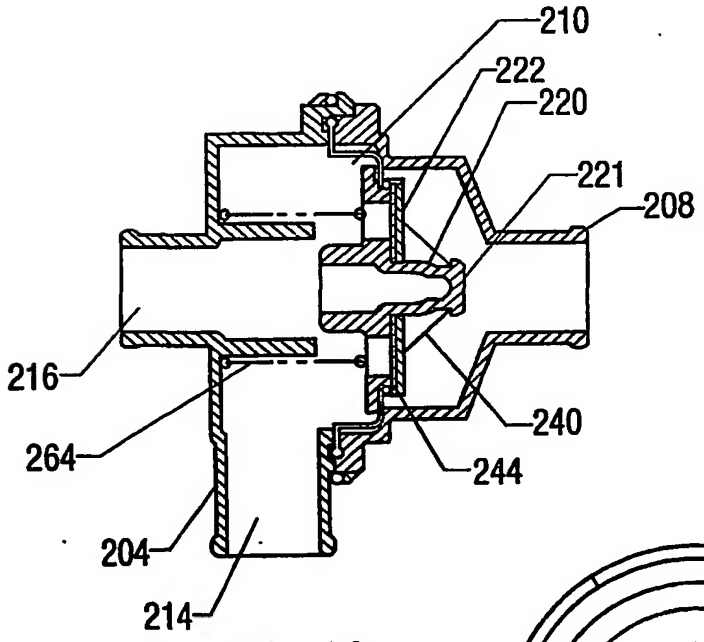

FIG. 16

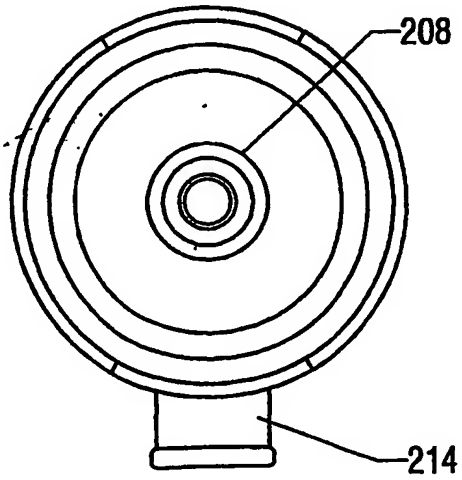

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/17008

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :F16K 17/00; G05D 16/06

US CL : 137/14, 115.15, 116.5, 505.11; 123/574

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 137/14, 115.15, 116.5, 505.11; 123/574

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 3,906,982 A (FLEISCHHACKER et al.) 23 September 1975, col. 5, line 38 to col. 6, line 58.	1-4, 6, 11-15, 17 ——— 7, 18
X	US 4,760,833 A (TATYREK) 02 August 1988, col. 4, line 46 to col. 5, line 37.	22
A	US 5,307,834 A (TATAREK-GINTOWT et al.) 03 May 1994.	1-24

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 20 JULY 2001	Date of mailing of the international search report 08 AUG 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer STEPHEN M. HEPPERLE Diane Smith Telephone No. (703) 308-1051

Form PCT/ISA/210 (second sheet) (July 1998)*